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Multi-tier Cropping System for Profitablity and Stability in Bt Cotton Production

Edited by

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FOREWORD

Economy of country is to be improved through agriculture by better utilization of natural resources and other inputs. Thus, production per unit area of land, time and inputs should be increased by improving efficiency of the rate and extent to which solar energy is harvested for conversion to economic produce. The strategy for this is to have good canopy cover right from the planting of the crop to harvest. This is possible through intensive cropping involving crop mixers wherever feasible. This will not only improve the crop production in sustainable way but also economize the crop production.

Since cotton is a crop of relatively longer duration, its slow initial growth offers a vast scope for cultivation of suitable vegetable intercrops. India is the second largest producer of vegetables in the world, with an annual production of 101.43 m T from an area of 6.75 m ha. Our requirement of vegetables has been increased to about 127.2 million tonnes to meet the nutritional requirement of an estimated 1200 million population expected by 2020-21.. In addition, although vegetables have high production potentials, yet biological risk, perishability, fluctuating price are the limitation that pose major constraints in vegetable production in the country. Thus, keeping in view better utilization of resources, multiple intercrops are aimed for increasing input use efficiency and resource utilisation. An ideal cotton based multitier intercropping should aim to produce higher economic return and yields per unit area, offer greater stability in production, meet the domestic needs of the farmer and provide suitable distribution of farm resources. Cotton based multi tier intercropping system with vegetables was developed through rigorous testing under irrigated condition at CICR, Coimbatore. The technical and economic feasibility of multi tier systems were discussed in the bulletin by including background, advantages, method of establishment and input requirement. The performance of the systems was assessed in terms of growth, yield, quality, input use, production and economic efficiency and stability. The publication is useful for extension workers to promote annual cotton based multi tier cropping system and also act an impetus for further relevant research.

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1. Introduction

The demand for agricultural commodity is growing world over and to meet the ever increasing targets as per the demand, productivity needs to be raised further. This can be realized in two ways-by increasing area of cultivation and/or through increased efficiency of inputs (both natural and manmade). The scope for the former is very limited worldwide and for the latter, the primary input is the solar energy which is most abundant except in few cases like colder regions. Thus, production per unit area of land, time and inputs can be increased by improving efficiency of the rate and extent to which solar energy is harvested for conversion to economic produce. The strategy for this is to have good canopy cover right from the planting of the crop to harvest. This is possible wherever feasible through intensive cropping involving crop mixers. In multiple cropping systems, the possibility of more efficient use of resources like sunlight, nutrient and water is higher leading to increased biological diversity and higher production stability. Monocropping is exception while mixture (of species) is the rule of nature. Reviewing cropping system in South Asia, it is observed that intercropping is a well established practice covering over 12 m ha .

In multiple cropping systems, the possibility of more efficient use of resources like sunlight, nutrient and water is higher leading to increased biological diversity and higher production stability.

On the status, India ranks first in world acreage (10.2 m ha) with almost 33 % of total cotton area. Since cotton is a crop of relatively longer duration, its slow initial growth offers a vast scope for cultivation of suitable vegetable intercrops. India is the second largest producer of vegetables in the world, with an annual production of 101.43 m t from an area of 6.75 m ha. Our requirement of vegetables has been increased to about 127.2 million tonnes to meet the nutritional requirement of an estimated 1200 million population expected by 2020-21. Although the productivity levels of vegetables have increased manifolds, it won't be sufficient to feed ever increasing population as a result of increased demands. This will complicate the issue of price rise further leading to increased costs of vegetables. In addition, although vegetables have high production potentials, yet biological risk, perishability, fluctuating price are the limitation that pose major constraints in vegetable production in the country.

Thus, keeping in view climatic vulnerability, market fluctuation and better resources use, cotton is chosen as a candidate crop and cotton based system with multiple intercrops is aimed at for increasing input use efficiency. In addition, the root systems of the component crops are also located at distinct zones so as to explore the soil for moisture and nutrients. An ideal cotton based multitier intercropping should aim to produce higher economic return and yields per unit area, offer greater stability in production, meet the domestic needs of the farmer and provide suitable distribution of farm resources. The combination of crops with diverse features (growth habit, root depth an duration) such as coriander, radish, beet root and cluster bean, were useful in studying their suitability under multi-tier system with the prevalent Bt (*Bacillus thuriengensis* L.) cotton. These intercrops were observed to

serve as an insurance against the menace of pest and disease, vagaries of weather, market fluctuation and help to increase the net profit to growers.

2. Advantages multi tier systems

- High productivity and potentiality
- High profitability
- Enhanced input use efficiency
- Stability and sustainability achieved
- Employment opportunity to farm family
- Flow of income during cropping periods

3. Proven multi tier cropping system

Cotton based multi tier intercropping system with vegetables were developed through rigorous testing of eight cotton based systems in comparison to sole cotton under irrigated condition of south zone with Bt hybrids . The following prominent systems (two) proved its economic viability and sustainability. The recommended two systems were discussed in the bulletin elaborately in comparison to sole cotton.

Cotton +radish + cluster bean+ beet root (Fig.1)

Cotton +radish + beetroot +coriander (Fig.2)

4.Genotypes

Cotton (*Gossypium hirsutum* L.) hybrid 'RCH–20 Bt', coriander (C*oriandrum sativum* L.) cultivar 'SURABHI', radish (*Raphenus sativus* L.) cultivar 'PUSA CHETKI', beet root (*Beta vulgaries* L.*)* cultivar 'DDR', and cluster bean (C*yamopsis teragonolaba* L.) cultivar 'PUSA NAVBAHAR',' were tested in the recommended systems

5. Fertiliser levels

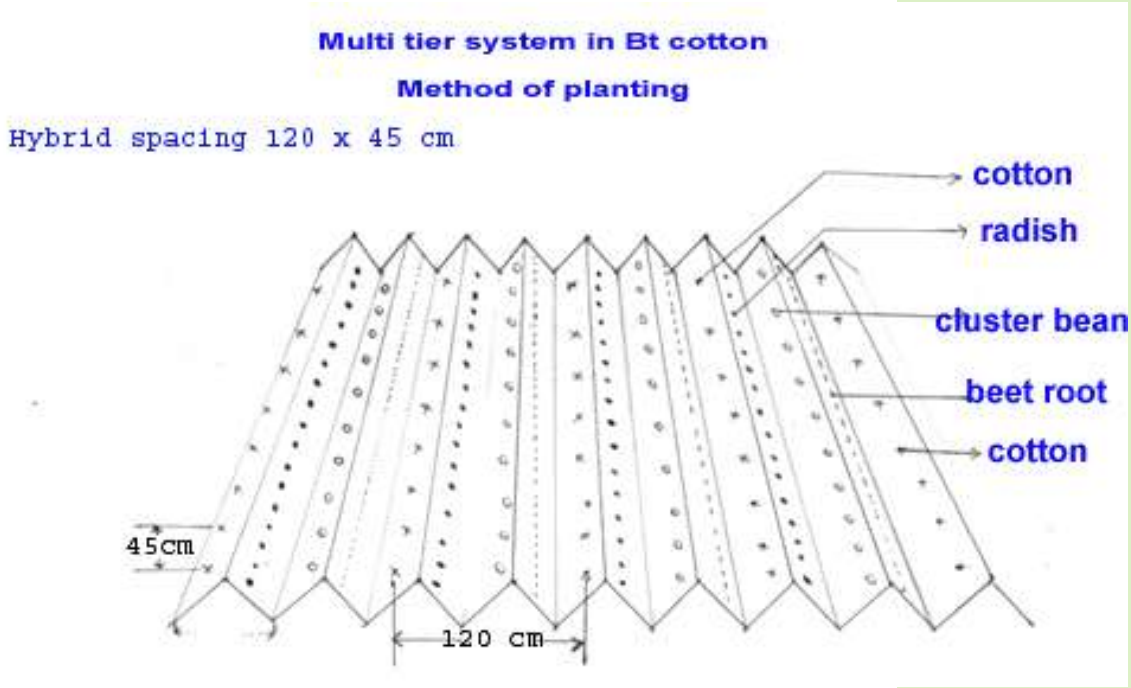
An uniform fertilizer doze of 90:45:45 kg N:P_2O_5:K_2O per hectare is recommended in all the system in addition to the recommended NPK level for intercrops (viz., coriander (3.3:6.6:0), radish (3:12.5:6) , beet root (15:40:25), and cluster bean (9.3:18.5:9.3). The total N to the system has to be applied at two equal splits, first at the time of planting and second on 40 DAS (days after sowing), while entire P and K has to be applied as basal at the time of planting.

6. Methods of planting followed

The field was ploughed once with tractor drawn mould board plough and then harrowed twice. Bt Hybrid was planted at 120 x 45 cm, where two ridges at 60 cm apart were formed, and

various intercrops (three crops) were planted on 4 sides of the 2 ridges in sequence (Fig.3). Radish, coriander and others vegetables (beet root and cluster bean) were planted at intra-row spacing of 10, 15 and 20 cm respectively. No additional irrigation was provided for the intercropping systems (similar to sole cotton crop).

Fig. 3 Method of planting in multi tier cropping system



7. Performance of multi tier cropping systems

7.1 Cotton

7.1.1Growth characters and yield

Growth characters, yield attributes and seed cotton yield (Table 1) showed that none of the attributes could significantly influenced by the performance of multi-tier cropping systems. As a result seed cotton yield for systems were 25.45 to 25.85 q ha^{-1} and sole cotton yield of 26.15 q ha^{-1} was recorded. Since the component vegetable inter-crops viz., coriander within 30- 45 DAS, radish at 45 DAS, cluster beans and beet root within 75 DAS were harvested, none of the above crops competed with the main crop of cotton during the growth and development. As a result, almost statistically similar growth characters, yield attributes and seed cotton yield were recorded in base crop cotton under inter/ sole crop systems. Thus, intensive cropping systems through crop mixer was successful as the components in the system have different nutrient and moisture requirement, varied feeding zones in the soil profile, differential growth duration for enabling the utilization of natural resources optimally.

intensive cropping systems through crop mixer was successful as the components in the system have different nutrient and moisture requirement

Table 1 Growth characters and yield as influenced by multi tier systems

Multi tier systems	Dry weight (kg/ha)	No of bolls	Yield per plant (g)	Seed Cotton yield (q/ha)
T1. Cot +rad + c. bean+ b. root	5115	29.6	134.3	25.45
T2. Cot +rad. + b.root +coriander	6015	31.7	142.7	25.85
T3. Sole cotton	7773	30.4	145.1	26.15
CD 5%	NS	NS	NS	NS

7.1.2 Quality parameters

The modification/ changes of management practices might have specific impact on cotton quality parameters which needs further assessment. System analysis revealed that none of the above cotton quality parameters were influenced by intercropping system, since resilience genetic nature of the above parameters was not altered by these agronomic manipulation. Mean fibre quality values recorded under the inter-crops (Table 2) varied for 2.5 % span length (30.9 to 31.5 mm), maturity ratio (0.76 to 0.80), uniformity ratio (47.3 to 49.2 %), micronaire (4.2 to 4.3 µ in^{-1}), fibre strength (21.3 to 21.9 g/tex), FQI (330.2 to 335.5), count (47 to 51 %) and CSP (2158 to 2196). Fibre quality being mostly genetically inherited, the response was not distinct.

Table 2 Quality parameters of cotton as influenced by multi tier systems

Multi tier systems	2.5% span length (mm)	Mic. (µ/inch)	Fibre strength (g/tex)	FQI
T1. Cot +rad + c.bean+ b. root	30.9	4.2	21.9	330.2
T2. Cot +rad. + b.root +coriander	30.9	4.2	21.6	325.7
T3. Sole cotton	31.5	4.3	21.3	335.5
CD (5%)	NS	NS	NS	NS

7.2 Intercrops

Yield (kg ha^{-1}) of vegetable intercrops (Table 3), found that system involving , Cotton +radish + cluster bean + beet root had been recorded yield of radish (6660 kg ha^{-1}) , cluster bean (4536 (kg ha^{-1}) and beet root (5671 (kg ha^{-1}) . The other prominent system harvested vegetable yield of radish (5091(kg ha^{-1}), beet root (5347 (kg ha^{-1}) and coriander (3536 (kg ha^{-1}).

Table 3 Yield and economics of cotton and intercrops in multitier system

Multi tier systems	Yield (kg/ha)	Gross Return (Rs/ha)	CC (Rs/ha)	Net return (Rs/ha)	B/C ratio	SCEY (q/ha)
T1.Cotton	2545	51980	28680	23301	1.8	25.5
Radish	6660	29969	5823	24146	5.1	14.7
Cluster bean	4536	32888	11489	21399	2.9	16.1
Beet root	5671	35442	5055	30386	7.0	17.4
T2.Cotton	2585	52950	28353	24598	1.9	26.0
Radish	5091	22908	4820	18088	4.8	11.2
Beet root	5347	33421	4857	28564	6.9	16.4
Coriander	3536	22987	3901	19085	5.9	11.3
T3. Cotton	2615	53320	29038	24282	1.8	26.1

multi-tier cropping system of cotton + radish + cluster bean + beet root registered the highest gross and net return, seed cotton equivalent yield (17.4 q ha^{-1})

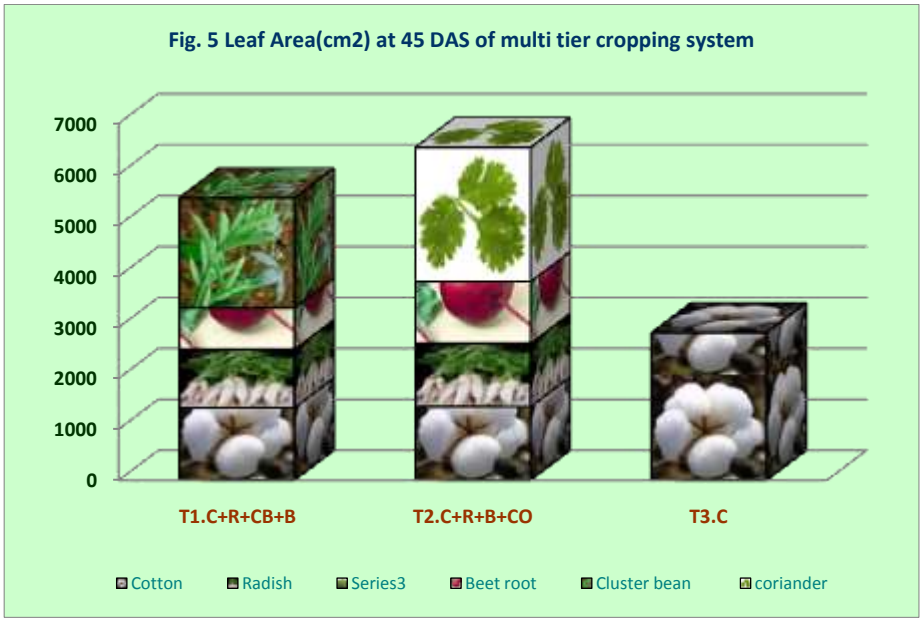
Pure crop raised along with experiment recorded yield (kg ha^{-1}) of vegetables, radish, beet root, cluster bean, and coriander were 21475,17123,7585 and 15142 respectively.

Thus, the economics of intercrops alone revealed that beet root harvested under the multi-tier cropping system of cotton + radish + cluster bean + beet root registered the highest gross return (35,442 Rs ha^{-1}), net return (30,386 Rs ha^{-1}), benefit cost ratio (7.0) and seed cotton equivalent yield (17.4 qha^{-1}). While calculating cost of cultivation for intercrops, cost of seeds, sowing charges, fertiliser and harvest charges of intercrops were only taken to the count for intercrops and all other items considered under base crop cotton, hence cost of cultivation is less with intercrops, which favoured for high net return, benefit cost ratio and seed cotton equivalent yield.

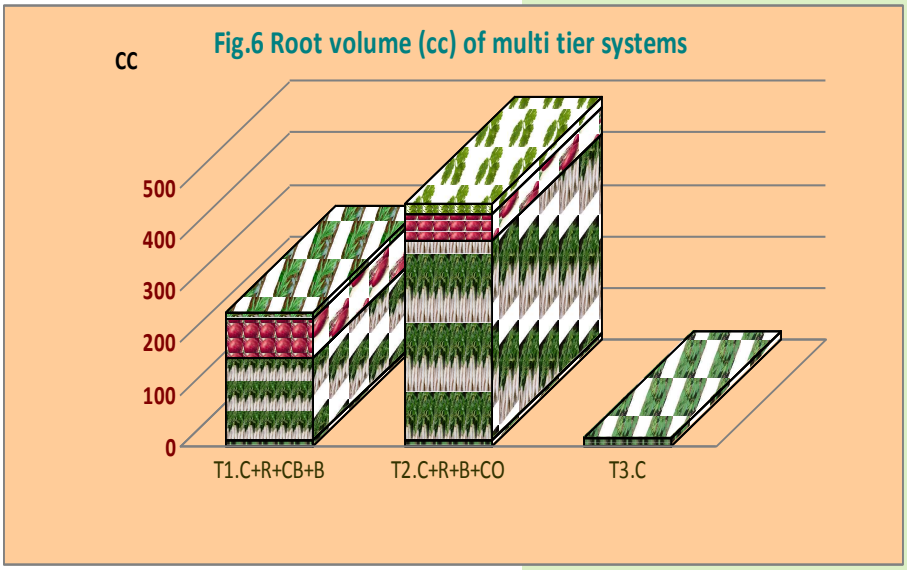
7.3 Multi tier (intercropping) system

The advantages of multi tier system are physically reflected from the differential growth characters of component crops. For example, mean plant height, root length and root volume (Fig.4) observed at 45 DAS were 24.4, 29.6 cm and 293.8 cc with radish, 33.6, 16.4 cm and 55.3 cc with beet root, 42.7, 20.2 cm and 10.7 cc with cluster bean, 22.7, 16.4 cm and 19.9 cc with coriander and 43.5, 20.1 cm and 12.4 cc with base crop cotton.

These variations resulted in formation of a multi-tier system. Root volume and LAI of the different system were worked out at 45 DAS by including respectively root volume and leaf area of base crop (cotton) and multitier forming intercrops (vegetables). It revealed that root volume and LAI were significantly influenced by the multi-tier systems as highest of root volume of 467.9 cc and LAI of 1.2 was with Cotton + radish + beetroot + coriander which in fact were 5.5 and 2.5 times than that in sole cotton (Fig.5&6) pooled mean data on per cent photosynthetic active radiation (PAR) interception showed that value of 68.7 was measured with the system with Cotton + radish + cluster bean + beet root and sole cotton registered 34.0 per cent. Higher LAI recorded in different multi tier systems also favored higher interception of light.



7.4 Weed smothering efficiency



Cotton (especially hybrids) is a widely spaced crop in India and it takes at least 90 days to cover the land area. The interspaces between cotton rows are occupied by weeds and compete with crop for nutrient, moisture, light and space and also act as alternate host for pest and disease. One of the best approaches for reducing problems caused by weeds is increasing the crop density either of sole crop or intercrop. Shading the top soil and competition for water and nutrients will certainly suppress weed germination and growth. In the current investigation also, cotton intercropped with radish, beetroot and coriander (T_2) registered the weed smothering efficiency of 33.8 per cent (Table 4& Fig.7). High foliage producing capacity of vegetable crops, suppressed the weed growth.

increasing the crop density either of sole crop or intercrop and shading the top soil and competition for water and nutrients will certainly suppress weed germination and growth

Table 4 Root volume, leaf area index and weed smothering efficiency of multi tier systems

Multi tier systems	Root Volume (cc) at 45 DAS	LAI at 45 DAS	Weed dry weight (kg/ha)	WSE (%)
T1. Cot +rad + c. bean+ b. root	256.2	1.0	552.1	28.1
T2. Cot +rad. + b.root +coriander	467.9	1.2	508.3	33.8
T3. Sole cotton	15.6	0.5	767.9	0.0
CD 5%	84.7	0.2	210.6	

LAI- Leaf Area Index, WSE- Weed Smothering Efficiency,

7.5 Production efficiency

Intercropping efficiency parameters measured through relative production (RPE) and economic efficiency (REE), land equivalent ratio (LER), diversity index (DI) and area time equivalent ratio (ATER) were also significantly improved with multi-tier intercropping system in comparison to sole cotton. Multi tier system of cotton + radish + cluster bean + beet root (T_1) was having the highest RPE, REE and LER of 182.2%, 308.7 % and 2.2 respectively (Table 5& Fig.8). Thus, the increased system efficiency was due to additional yield and return realised from intercrops. Diversity index (DI)- a measure of diversity with different systems- also revealed that cotton + radish + cluster bean + beet root (T_1) system had higher value (3.8) indicating the system was more diversified and sustainable one.

production efficiency measured through relative production (RPE) and economic efficiency (REE), land equivalent ratio (LER), diversity index (DI) and area time equivalent ratio (ATER) were also significantly improved with multi-tier intercropping

Many times, sustaining yield from a farming system in totality may be of prime consideration for farmers under resource scarce condition than maximizing yield or income from a single crop. The most interesting biological and economic aspect of multi-tier intercropping is the potential for compensation among the components of the system, often referred to as biological or economic "buffering" in the system that leads to greater stability in (total) yields of component crops. Amongst the multi-tier systems, Cotton + radish + cluster bean + beetroot had higher area time equivalent ratio (ATER, 1.5). ATER provides more realistic comparison of the yield advantage of intercropping over monocropping since it takes into account both area and time taken by the component crops in an intercropping.

Table 5 Production and economic efficiency of multi tier systems

Multi tier systems	RPE (%)	REE (%)	LER	ATER	DI
T1. Cot +rad + c. bean+ b root	182.2	308.7	2.2	1.5	3.8
T2. Cot +rad. + b.root +coriander	148.4	272.0	1.8	1.3	3.5
T3. Sole cotton	0.1	0.0	1.0	1.0	1.0
CD 5%	17.1	42.3	0.4	0.3	0.5

RPE-Relative Production Efficiency, REE- Relative Economic Efficiency, LER-Land Equivalent Ratio, ATER- Area Time Equivalent Ratio, DI- Diversity Index

competition for light was minimized and total interception increased and water use efficiency as well as water productivity were influenced significantly by multi-tier cropping systems

7.6 Input use efficiency

7.6.1 Light

Unlike rainfall and nutrients, use of solar energy is limited to be captured and stored for latter use in the way that other natural resources are managed as light is instantaneously available and needs to be instantaneously intercepted and used. In the current investigation, higher percentage of light interception was observed at 45 DAS with multi-tier system of cotton intercropped with radish, cluster bean and beetroot (68.7 % Table 6.). Under multiple cropping situations, the component crops were grown in such a way that competition for light was minimized and total interception increased. Since the least light interception (34.0) was observed with sole cotton, the efficiency was not much higher in sole cotton mainly because of slow ground coverage by cotton foliage.

Fig.9 Sole cotton

7.6.2 Water

Being a costly and scarce resource, irrigation water and its availability for agriculture is expected to go down further due to increased domestic and industrial demands. Water use efficiency (WUE, kg $ha^{-1}cm^{-1}$) and water productivity (WP, Rs m^{-3}) were influenced significantly by multi-tier cropping systems. As a result, highest water use efficiency of 108.2 kg $ha^{-1}cm^{-1}$ and water productivity of Rs 22.1 m^{-3} of water used were calculated with cotton + radish + cluster bean +

beet root (T_1, Table 6). Sole cotton system (Fig.9) produced only 38.4 kg by using of one hectare centimetre of water while gross return of Rs 7.8 per hectare was realized for m^3 of water (1000 litres). Thus, most efficient cropping pattern is one, which capable of giving maximum return per unit quantity of water.

multi-tier intercropping of cotton + radish + cluster bean + beet root gave the highest partial factor productivity of nutrient and economics of nutrient use efficiency per rupees invested on fertiliser

7.6.3 Nutrients

Nutrient use efficiency of multitier system was assessed by calculating the partial factor productivity (kg kg^{-1}) and economics of nutrient use efficiency (kg Rs^{-1}) and found that both the indices were significantly influenced by multi-tier cropping systems. Multi-tier intercropping of cotton + radish + cluster bean + beet root (T_1, Table 6) gave the highest partial factor productivity (PFP) of nutrient (23.1 kg per kg of nutrients) and economics of nutrient use efficiency of 1.67 kg seed cotton per rupees invested on fertiliser were arrived

Table 6 Input use efficiency of multi tier systems

Multi tier systems	LI (%)	WUE (kg/ ha-cm)	WPY (Rs/M3)	PFP (kg/kg)	ENUE (Kg/Rs)	Labour (MD/ha)
T1. Cot +rad + c. bean+ b. root	68.7	108.2	22.1	23.1	1.67	484
T2. Cot +rad. + b.root +coriander	63.7	95.2	19.4	22.0	1.60	367
T3. Sole cotton	34.0	38.4	7.8	14.5	1.14	284
CD 5%		13.7	2.8	2.4	0.6	

LI- Light Interception, WUE- Water Use Efficiency, WPY- Water productivity PFP- Partial Factor Productivity, ENUE-Economies of Nutrient Use Efficiency

7.6.4 Labour

High productive multi tier system involved intercropping of cotton + radish + cluster bean + beet root (Table 6) requires 484 man days as compared to sole cotton (284). Labour intensiveness associated with multi-tier systems was analysed and it was observed that labour use efficiency in term of gross return per labour was higher with systems. Amongst intercropping systems, the highest labour use efficiency of Rs 310.5 per labour (of 8 hours) was arrived at with cotton + radish + beet root + coriander and sole cotton system had value of Rs 184 / labour.

7.6.5 Pest population

The monoculture was criticized because of the fact that their genetic uniformity resulted in continuous pest susceptibility. Intercropping is one of the important cultural practices in pest

management and is based on the principles of reducing insect pest by increasing diversity of eco-systems. However, significant differences in pest population in respect of jassid, whitefly, and aphids and other beneficial insect population of lady bird beetle and spider were not observed in the different cropping systems at 45 DAS. Bt cotton seed is treated with imidachloprid (as mandatory) used that might not allowed sucking pests to cross the ETL especially at initial stage. This caused non-occurrence of sufficient pest load, ultimately resulting in to less number of beneficial insect population during the observation period.

intercropping is one of the important cultural practices in pest management and is based on the principles of reducing insect pest by increasing diversity of eco-systems

7.7 Nutrient available and uptake

Multi-tier intercropping system are highly intensive in nature and their impact on productivity of the soil needs to be assessed. Distinctive feature of most members of the *fabaceae* (pulses sub-family) is the capability to fix atmospheric N_2 biologically by prime modulators and inclusions of legumes are useful in maintaining soil fertility. The least soil available N (174.5 kg/ha) and K (690 kg/ha) were estimated with high productive system consisting of multi-tier one viz., cotton + radish + cluster bean + beet root (T_1), However, which was on par with sole cotton with respect to soil available nitrogen (Table 7).

Table 7 Nutrients status of post harvest soil under multi tier systems

Multi tier systems	Available Nutrients (kg/ha)		
	N	P2O5	K2O
T1. Cot +rad + c. bean+ b. root	174.5	17.9	690.5
T2. Cot +rad. + b.root +coriander	177.5	18.6	692.0
T3. Sole cotton	187.1	17.5	788.4
CD (5%)	15.0	NS	49.0

ability of intercropping system to make more efficient use than sole crops was evident both for soluble and non-soluble nutrients

NPK uptake of multi-tier system results revealed that cotton intercropped with radish, cluster bean and beetroot (T_1) had higher uptake of 192.5, 36.4 and 206.1 kg ha^{-1} in terms of N, P & K respectively whereas sole cotton removed only 102, 19.2 and 82.8 kg of the above nutrients respectively (Table 8). Thus, the ability of intercropping system to make more efficient use than sole crops was evident both for soluble and non-soluble nutrients. Because of different root growth pattern of component species, intercropping also explores the entire soil mass in the rooting zone. This was also ascribed to the more availability and absorption of nutrient under intercropping situation.

Table 8 Nutrient uptake of multi tier systems

Multi tier systems	Nutrient Uptake (kg/ha)		
	N	P	K
T1. Cot +rad + c. bean+ b. root	192.5	36.4	206.1
T2. Cot +rad. + b.root +coriander	166.8	27.6	157.9
T3. Sole cotton	102.0	19.2	82.8
SEd	10.6	4.7	10.7
CD (5%)	21.6	9.6	21.7

7.8 Economics

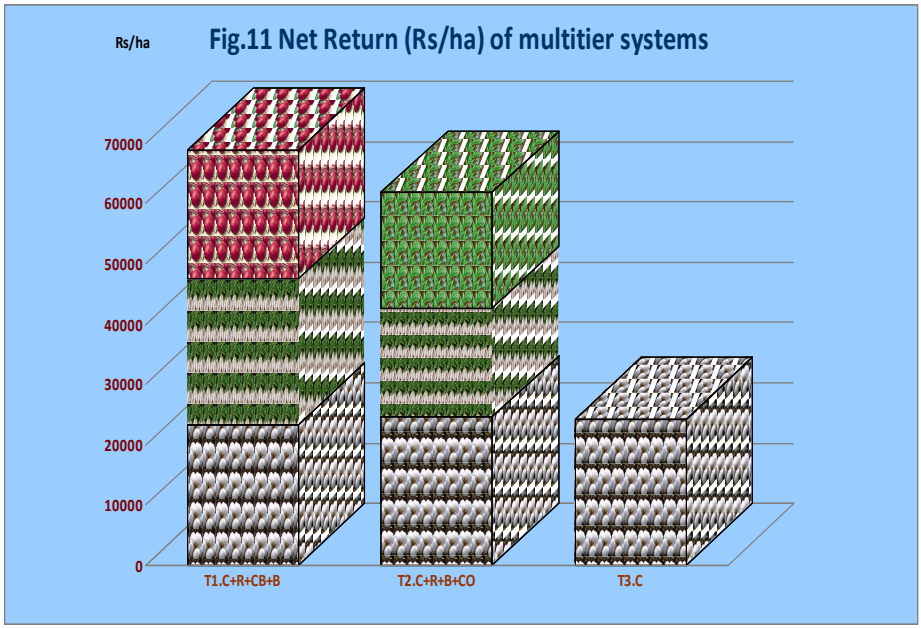
The multi-tier system significantly increased gross return, net return, BCR, per day profitability and seed cotton equivalent yield. Highest gross return (Rs 1,50,278 ha^{-1}) , net return (Rs 99,232 ha^{-1}), per day profitability (Rs 662 day^{-1}) and seed cotton equivalent yield (73.7 q ha^{-1}) were obtained with multi-tier system of cotton+ radish +cluster bean+ beet root (Table 9 and Fig.10,11,12&13).

Table 9 Economics of multi tier systems

Multi tier systems	Gross Return (Rs/ha)	Net return (Rs/ha)	B/C ratio	SCEY (kg/ha)
T1. Cot +rad + c. bean+ b. root	150278	99232	2.9	73.7
T2. Cot +rad. + b.root +coriander	132266	90334	3.2	64.8
T3. Sole cotton	53320	24282	1.8	26.1
CD 5%	15518	14640	0.2	7.2

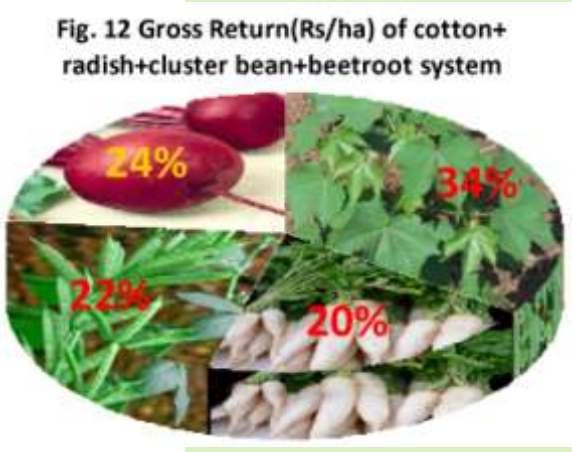
SCEY- Seed Cotton Equivalent Yield,

The system (T_1) was more efficient as it enhanced gross return, net return, BCR, per day profitability and seed cotton equivalent yield @ 281.8, 408.7, 161.7 408.6 and 282.3 per cent respectively in comparison to those in sole cotton. Intensification of crop on time and space dimension in the system (T_1) by selecting short duration, non competitive crops and method of planting adopted could not suppress growth of the base crop and produce statistically as much as equal seed cotton yield (25.5qha^{-1}) as that of sole crop in addition to supplementing it by vegetable yield.



These included production of 6.66 t $ha^{-1}$of radish, 4.54 t ha^{-1} of cluster bean and 5.67 t $ha^{-1}$of beet root, which favoured for higher economic return. Sole cotton registered the lower values of net return (Rs. 24, 282 ha^{-1}), BCR (1.8) and per day profitability (162) and seed cotton yield (26.1 qha^{-1}).

On the similar lines, cropping system did not influence seed cotton yield but additional yield of intercrops make system more remunerative over the sole cotton. This may be also attributed to differential growth peaks in the selected crops



in the intercropping involving radish, cluster bean and beet root that coincided with lag phase of the cotton and helped in avoiding competition among the components and main crop resulted in higher production and economic return.

Fig.13 Net Return(Rs/ha) of cotton+ radish+cluster bean+beetroot system

8. Summary and conclusion

Multitier cropping systems are dynamic interactive practices aimed at better use of the production components such as soil, water, air space, solar radiation and all other inputs on sustainable basis. Highest gross return, net return, per day profitability and seed cotton equivalent yield were obtained with the multi-tier system of cotton+ radish+ cluster bean + beet root. The introduction of non competitive, short duration, multi intercrops into sole cotton, salvaged the risk perturbed by mono-cropping. Higher production, economic return and resource utilisation realised with multi-tier system of Bt cotton+ radish+ cluster bean+ beet root were advantageous in more than one ways. Thus, higher yield and profit could be realized with the introduction of multi-tier cropping in a unique tier-arrangement in Bt cotton hybrids under irrigated condition, the bulletin suggested.

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